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Session 12: Conservation Agriculture: Producer Adoption

ORAL ABSTRACTS

Adoption of Innovative Technologies

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Rice is the staple diet for nearly one-half of the world population, particularly in Asia. Rice is also gaining in popularity in Africa, where over 26 million metric tons were produced in 2012, primarily for domestic consumption.

There are two rice production systems—upland and lowland (or flooded). The latter is more predominant. In both systems, commercial fertilizer is broadcast two or three times during the growing season. This method results in low-nutrient use efficiency; in flooded rice systems in Asia, the efficiency of urea, the most widely used nitrogen fertilizer, is no more than 30 percent. Several slow- and controlled-release fertilizers have been tested, but none are economically viable for smallholder farmers in Asia or Africa.

IFDC has developed and tested an innovative technology that significantly increases fertilizer productivity. This technology involves sub-surface placement of fertilizers in a single application during the growing season. This technology is being evaluated and adopted at a rapid rate in several less-developed countries. For example, in Bangladesh, this technology is being used by more than 2.8 million farmers on 1.5 million hectares.

This presentation discusses the development of this technology, its packaging and the dissemination of the information, including policy analysis leading to the adoption by producers and, in particular, challenges to that adoption.

Conservation Agriculture: A Precision Farming Tool for Smallholders

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Introduction

Globally smallholder farmers constitute the majority of farmers, producing 80 percent of the food in developing countries. Yet, for many, farming is a struggle often with only rudimentary tools and implements available. As a group they can pay little attention to the longer term management of natural resources and can rarely afford inputs such as quality seeds or fertilizer, let alone herbicides for chemical weed management.

The scarcest input to smallholder farming is often energy, particularly the human energy or farm power that is required for land preparation, crop establishment, weeding, harvesting and transport. Many smallholder farmers are women and youth who carry the major burden of arduous hand labour and is a main reason why rural youth in developing regions migrate to urban areas in search of an alternative to rural smallholder agriculture. Conservation Agriculture (CA) presents an opportunity for smallholders to reduce or even eliminate the need for land preparation and heavy digging. Applying precision agriculture (PA) principles to smallholder farming (for example for crop establishment, fertilizer and agrochemical application and irrigation) enables farmers to participate in technology development at their scale of operation. Yet, often the global stakeholders in agricultural technology development, especially private sector input and equipment suppliers are not willing or are unable to reach out to the majority of smallholders in rural areas of much of Africa and Asia.

Examples of Precision Agriculture in CA:

Precision planters. CA embraces the concept of sustainable production intensification by reducing labour and farm power inputs, with more precise seed placement and fertilizer application as well as the judicious use of herbicides for weed management as a complement to agronomic controls such as soil cover and cover crops.

No-till planters have been developed for all farm power levels (manual, draught animal and tractor). The following are some examples and what is common to all is the use of a method for the precise placement of seeds and the simultaneous application of a precise rate of fertilizer.

The *matraca* or hand jab-planter comes from Latin America where the traditional tools (for use in tilled soil) have been modified in order to be able to plant through crop residues and crop cover. It has two hoppers, one for seed and one for fertilizer which allows for planting and fertilizing in one pass. Small-scale farmers, especially women, like it because of the labour savings due to the elimination of the arduous hand hoeing for land preparation. The simultaneous and precise placement of fertilizer makes the *matraca* truly a precision agriculture tool for smallholder farmers.

A new type of hand jab planter (The Yunfan of Chinese design) is now available for smallholder farmers at commercial scale.

Herbicides for weed management. The use of herbicide for weed management in the context of smallholder farmers is a hotly debated topic. However hand weeding is the second most arduous task (after hand digging) and it is mostly done by women and children and so the judicious use of herbicides is becoming more widespread and acknowledged as a modern and drudgery relieving means for weed

management besides other agronomic measures and practices such as applying mulch for soil cover and living cover crops for weed suppression through competition for resources, including sunlight.

Today the hand carried knapsack sprayer is the most common tool for smallholders for applying herbicides. Newer models come with accumulator pumps that eliminate the tiresome hand lever operation. The application of herbicides requires knowledge on the correct calibration and field use of the sprayer. For blanket coverage with a total herbicide it is useful to install a spray boom onto the knapsack sprayer which can also be fitted to a wheeled chassis for even safer and more precise application.

For larger fields and potentially for service providers there are single axle boom sprayers available for draught animals; the work efficiency increases with the wider boom and bigger tank. Farmers' fields need to have a sufficiently large area with even surface topography.

Weed mapping and N application. A new way of making the application of herbicides for weed management as efficient and precise as possible is emerging for larger scale sprayers. It is acknowledged in commercial agriculture that blanket coverage of a fallow with herbicides is expensive and not in line with efficient and precise application of inputs, neither is it in line with sustainable intensification. Therefore, selective spot spraying is now applied with the use of new tools such as the 'WeedSeeker'. The WeedSeeker technology employs sensors and evenly spaced spray nozzles. The sensors work on the principle of reflecting red and near infrared light (from a light-emitting diode – LED) off a weed beneath. When a green plant is identified (through an on-board analysis of the reflected light) the spray nozzle is activated. Use of the similar GreenSeeker can optimize N application to growing crops.

Conclusions

PA is being promoted in order to use fertilizers, water and other expensive inputs more efficiently. Smallholder farmers need to be better integrated into the precision farming discussion. PA has mainly looked at higher input use efficiency and at reducing the environmental footprint of chemical inputs, but PA practices can also enable smallholder farmers to use their limited farm power resources more effectively and efficiently.

Joint efforts of development partners, private sector and local entrepreneurs are required to connect smallholders to technological innovations in agriculture. The major global private sector suppliers of such innovations should be encouraged to make efforts to reach smallholders with targeted equipment lines, geared towards the sustainable and efficient use of natural resources and a gradual production intensification and modernization of smallholder farming.

PA tools should be applied within a system or toolbox of agronomic and management options. An improved tool or implement on its own will not make a difference, it has to fit with the concept of sustainable agricultural intensification.

Farmer Development and Uptake of Zero Tillage in Mosul Iraq 2006-2014

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Background

Since zero tillage (ZT) technology was first introduced to Iraq in Ninevah Governorate through an AusAID/ACIAR funded project in 2006/2007, a group of Mosul farmers, who received training in Mosul, Syria, and Australia, has been testing and adapting technology, and addressing the major adoption constraint of access to effective and affordable ZT seeders and practices. This has involved farmer field trials and demonstrations comparing ZT and traditional cultivated systems, modification of traditional seeders to ZT, and local manufacture of tines, openers, press wheels and eventually complete seeders, different ZT crop rotations, using Glyphosate for weed control, and wider rows. Sinan Jalili, a Mosul farmers' group member, took the opportunity offered by the project to join the Fifth World Congress of Conservative Agriculture 2011 to present a paper titled "**Farmer innovation: seeder fabrication and zero tillage uptake in Iraq**" and undertake a field tour of ZT research and development and seeder manufacture in South Australia. Since then, the farmer group has continued to develop and promote the technology together with University of Mosul and Ministry of Agriculture colleagues, and grew over 5000 hectares of rain fed and supplementary irrigation land, through the drought in 2011/12 and a good harvest in 2012/13, providing on-going and successful field demonstrations encouraging neighboring farmers to adopt ZT. They also held four annual field days, showing colleagues new concepts and new machines. They continued efforts to fully manufacture local 2.0 m wide ZT seeders from scratch, including tines and openers/points, using CAD drawings and newly introduced plasma-cutting machines. The group is also helping spread the technology into other places in Iraq, working with ICARDA to modify a RAMA seeder to ZT in Erbil Kurdistan, and manufactured in 2013 "Ras Al-Rumuh" seeder to work in Anbar province.

ZT APPLICATION ROAD MARKS

More Involved

Since 2011 the group became more involved in locally manufacturing prototypes for tines, press wheels, and complete small seeders designed on ZT standards of stubble handling, less disturbance, and changeable row spacing. Two locally manufactured prototype small seeders are available and working, and three prototypes for press wheels and tines have been tested and being used. Through this process, in 2011, the group induced new merchandise to Mosul Iraq, by importing, with the help of the AusAID/ACIAR funded project, but on their expense, tines, narrow points, and tires for press wheels, all that cannot be made in Iraq. They tested them for season 2012/2013, and were used widely by the project for the elaborate manufacture and modification scheme later.

More Initiation

The group went further to invest in buying a direct sowing seeder for (3500$), and sent it to Hamdaniya area, east of the city of Mosul, to be used this season by a local farmer for sowing 100 hectares for ten small farmers. Some plots were directly sowed on harvest remains, some were fallow from previous season, and the others were conventionally ploughed, with different sowing rates (120kg-200kg per hectare). The act made a very good comparison among the farmers, who saw for themselves the good crop from germination towards harvest, despite the lower seed rate, and despite direct sowing. The local farmer witnessed a growth in numbers of farmers willing to seed conservatively. Previous similar acts were conducted in Namrud since 2011 (using the first manufactured prototype).

More Zero Tillage

Zero tillage is equally about weed control, crop rotation, and stubble retention. The group tested several different crop management options. They tried using glyphosate and mowing, instead of shallow plowing, to eliminate weeds in the fallows during wheat-fallow rotation, and in irrigated plots. Cost of 16$ per hectare for glyphosate is twice the cost of plowing, which makes it uneconomical alternative for rain fed big plots. Shallow plowing (8cm max. depth) could become, in this cases, the only solution. Poor diversity in demand for agricultural products in Mosul limits economic options for Zero till rotation crops. Group tried trigonella, rye, and peas as a ZT rotation crops. Lack of profitable Zero tilled rotation crops, especially in rain fed areas, promotes fallow, and is a bigger problem for plots under sprinkler irrigation, where potatoes and tomatoes crop rotation is growing. The group tried wider row spacing in 2012/13 by increasing the popular 18cm row spacing up to 27 & 30 cm for commercial production plots, and 36 cm for seed producing plots, with maintaining same number of plants per one meter (135kg/h for 18cm row spacing, 100kg/h for 27cm row spacing, and 60kg/h for 36cm row spacing). Seed economy was evident, and yield for the 27cm row spacing plots were among the best in the area. The 36cm row spacing suffered 25% yield drop . Down the road of adapting ZT system, the farmers had to struggle and adapt to local conditions and local customs in rural communities, especially; uncontrolled grazing of fallow and harvest remains. Grazing of the harvest standing residues, after the farmers gathers hay, can be hard to stop in many places.

Early ZT Implications

In addition to the ZT concept itself, the project brought to the farmers in Mosul the capacity to be more efficient in seeding, labor, and time usage. These factors are becoming more and more important for the local farmers due to the economic challenges, lack of labor and time due to security situations in the major cropping areas. It is becoming crucial to crop cheaper, with less labor, and faster if to crop at all. Crop rotations are growing more important for the ZT farmers, and hopefully will help diversify agricultural products in Mosul. New prototypes of seeders are introduced to agronomy, and to whatever industrial society we have in Mosul since early sixties of the 20th century. Farmer initiations independent from the official works can be considered a somehow political implication of the ZT act.

Conclusions

Locally manufacturing seeders, tines, narrow points, and press wheels based on knowledge and experience from training and contact with ICARDA expertise, established sustainable infrastructure for ZT adoption in Mosul. making 16 ZT seeders for the project by the group, and nine seeders by another cooperating local shop resembles the peak of their efforts. ICARDA project appreciated the group enthusiasm, and responded with training and technical support, and helped the group manufacture and evaluate the prototypes. The group acted, through seven seasons of commitment to ZT, as examples for colleagues and neighboring farming communities. Active extension through field days and trials in other farmers' fields, using private resources, added to the ICARDA efforts promoting ZT in Mosul. Finding and helping innovative and interested farmers work for themselves and for colleagues and neighbors, proved to be the key for ZT promotion in Mosul. Other key aspects of ZT practice will need attention: weed chemical control, sowing wider rows, diverse ZT crop rotations, and awareness of the importance of stubble retention for soil and yield. Helping farmers to invest in new seeders, with aggressive extension in the fields, not limited to field days will be much needed in the following years. ZT is believed to be a promising answer for present and future challenges, and an entrance for more advanced farming for Mosul Iraq.

A Pragmatic Approach to Conservation Agriculture Helps Southern Australian High Rainfall Zone Farmers to Innovate Towards Productivity Gains

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Background

Grazing was the predominant form of land use in the high rainfall zone (HRZ) of Southern Australia since European settlement. For many years, less than 3% of arable land was used for cropping. The declining world market prices for wool triggered a massive cropping programme but was confronted with severe water logging as a result of the heavy and impervious clays of the Western Victorian Volcanic Plains. This became a serious hindrance to deriving any benefits from conservation agriculture (CA) practices.

Experimental Approach

Participatory Action Research saw the birth of Controlled Traffic (CT) Raised Beds in broad acre in the mid-nineties (Wightman et.al., 2005), which helped the more innovative farmers to immediately double their grain yields. Raised beds, while offering an insurance against total crop failure through better drainage and the accompanying increase in soil macro porosity, also offered opportunities for minimum tillage and more efficient stubble management while deriving the range of soil health benefits of conservation practice that would otherwise have not been possible under prolonged anaerobic conditions. However, there is now an appreciation that the current practices still do not fully utilise the soil profile which has the capacity to provide more than twice the plant available water capacity (PAWC) through appropriate practice change (referred to as subsoil manuring) that can be a part of the conservation agriculture package for the region. This is recognised as appropriate in a region that requires an adaptive strategy for a warming and drying climate, where yields are often limited by the lack of soil water during grain fill.

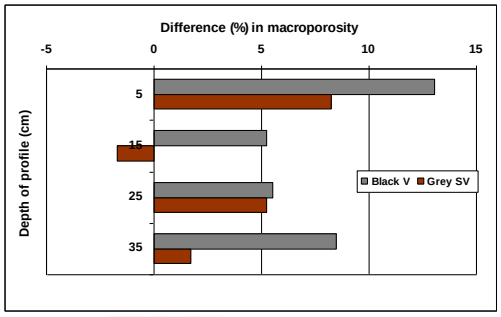
Applications and Implications for Conservation Agriculture

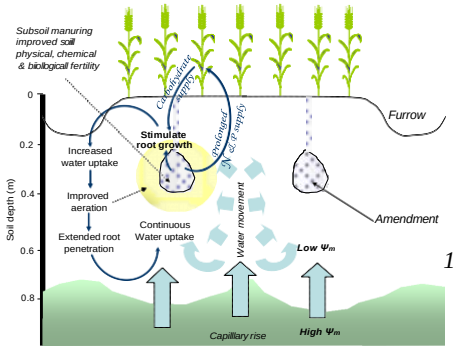
With raised beds came issues of heavy stubble loads and low harvest indices. Options for stubble management other than the conventional practice of burning, still present a challenge to farmers and so are the recent initiatives of using stubble as a subsoil ameliorant that may seem contrary to the concepts of CA. But our farmer approach has been more pragmatic than prescriptive. Better agronomy packages for raised beds and CT saw a steady increase in grain yields with the more entrepreneurial practitioners achieving upwards of 8 tha^{-1} regularly from their 2 and 3m raised beds. Controlled Traffic Farming (CTF) on the flat too has now continued for over 15 years in both 'low' and 'high' rainfall zones.

Results and Discussion

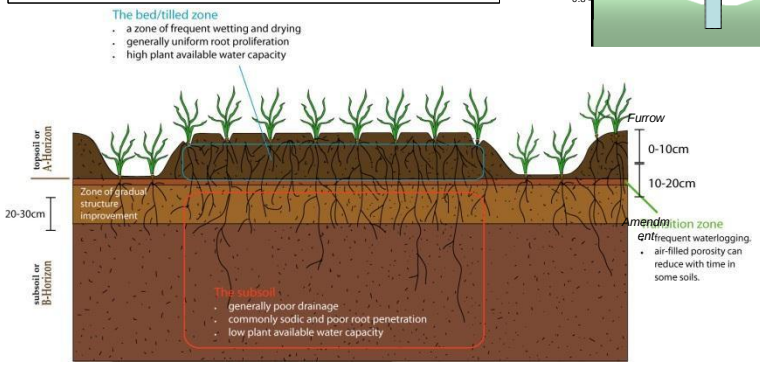
Different soils respond differently to raised beds. Our experience with sodic and non sodic Vertosols (Isbell, 1996) suggests that rapid drainage and the accompanying wet-dry cycles help increase the depth of aggregates (Sarmah et.al., 1996) and therefore the macro porosity of the soil (Peries & Gill, 2010). However, with dense and heavy clay subsoils, there can still remain a significant volume of

soil unexploited by the growing crops simply because of the lack of porosity resulting in high stubble loads, low harvest indices and low water use efficiency (WUE). The deep placement of nutrient rich organic manure or nutrient enriched stubble has shown to correct this impediment and is therefore appealing even to the traditional no-till farmers.





Figures (clockwise from bottom left): 1.Gradual root proliferation under raised beds with time. 2 Temporal change in soil macro porosity of two differently responding Vertosol soils (Peries et.al, 2004). 3. Theory of how deep placement of manures (subsoil manuring) change the soil physical structure with time and improves the plant available water capacity (after |Gill et.al., 2009)



Raised beds have taken yields to new high in soils prone to water logging but the expansion of raised beds in broad acre across Southern Australia have slowed down due to seasonal variability in rainfall patterns. However, the practice of subsoil manuring has shown yield increases in the order of 40% to 95% across sites and seasons presenting a promising practice where terminal droughts impact on heavy crops. The effects of this one-off practice has shown to persist beyond five years and is an attractive proposition even for no-till farmers, despite the initial deep ripping to place the amendment in the heavy clay subsoil. The research, development and delivery continuum of the initiatives are presented.

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Identifying Recommendation Domains for Conservation Agriculture in Eastern and Southern Africa

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Background

In many parts of Africa, inappropriate land use, poor management and lack of inputs have led to soil erosion, salinization, loss of vegetation, degradation of landscapes, and a decline in productivity (Abalu and Hassan, 1998; Thiombiano and Meshack, 2009). African soils are at risk and will not be able to sustain the ever-increasing human and livestock populations if traditional methods of management continue (Drechsel et al., 2001; Thiombiano and Meshack, 2009). Conservation agriculture (CA) is becoming one of the options in reducing soil degradation, enhancing crop productivity and maintaining yield stability (e.g., Kassam et al., 2009; Rockstrom et al., 2009). Although its contributions to reducing land degradation and increasing food security is well acknowledged, CA is not a remedy for all agricultural problems in all areas of Africa due to the heterogeneity of farming systems in terms of agroecological, socioeconomic and cultural environments, and resource endowment of farmers, farm management practices, and production strategies (Giller et al., 2006). The major constraints to CA adoption in Africa include the existence of severe competition for crop residue use as livestock feed and soil mulching (Jaleta et al., 2013), institutional factors (Mazvimavi and Twomlow, 2009) and limited access to input and outputs markets (Govaerts et al., 2009). In general, the impacts from CA crucially depend on the underlying biophysical and socioeconomic factors that influence the farming system. Understanding the interaction of biophysical and socioeconomic factors that influence the performance and adoption of CA systems could, therefore, allow for proper targeting of CA to places where it works well and could be adopted quickly. The objective of this study was to develop potential recommendation domains (RDs) for CA using geospatially referenced biophysical and socioeconomic variables in eastern and southern Africa.

Methodology

The study applied high resolution gridded biophysical and socioeconomic geospatial data in order to identify potential RDs for CA in Ethiopia and Kenya (eastern Africa) and Malawi (southern Africa). Smallholder agriculture plays a predominant role in the economy (24-43% of GDP) and livelihood of people (>70% of employment) in the three countries. In Ethiopia, agriculture is predominantly mixed crop-livestock system, where livestock is a major contributor to the sector, particularly in the form of power supply by draught animals. Like that of Ethiopia, Kenya's farming system is dominated by mixed crop-livestock systems and livestock plays an important role in the economy, particularly through the dairy sector. Unlike Ethiopia and Kenya, Malawi has low livestock densities and low demand for crop residues for livestock feed.

The biophysical criteria used were soil texture, surface slope and rainfall. The rainfall, slope and soil texture data collected for this study were classified into three (400-1000, 1001-1500 and >1500 mm), six (0-3, 0-7, 0-50, 3-7, 3-50, 7-50%), and three (sand and loamy sand, clay and other than sand, sandy loam and clay) categories, respectively. A factorial combination of these categories (layers) was used to identify the degree of biophysical suitability of cultivated areas to CA in the respective countries. The socioeconomic criteria used were access to market (as a proxy to transaction costs in accessing markets for inputs, outputs, and finance) and human and livestock population densities, which were classified into two groups each in order to evaluate the potential adoption of CA. Human population density wasclassified into high (>100) and low (≤100) persons per square kilometer, while the cattle density was classified into high (>50) and low (≤50) cattle per square kilometer. Market access was also

classified into two broader classes as 'accessible' if one-way walking to the market takes ≤3 hours (low transaction cost) and 'less accessible' if >3 hours (high transaction cost). High population density, low livestock density and better access to markets (low transaction costs) were taken as the combination of factors most favoring CA adoption, and *vice versa*. The biophysical data were used to identify suitable areas while combinations of biophysical and socioeconomic factors were used to develop potential RDs. The study considered all cultivated areas in the three countries although areas that receive annual rainfall of less than 400mm were considered as unsuitable to CA because of low biomass production.

Results and conclusion

Results show that about 84% of cultivated area in Malawi has a strong suitability to CA whereas suitable cultivated areas in Ethiopia and Kenya were found to be 43 and 55%, respectively. About 89, 51 and 26% of the cultivated areas in Malawi, Kenya and Ethiopia, respectively, showed high suitability with high or medium CA adoption potential. The results indicate that suitability and adoption potential of CA in Africa is high but differs among countries based on biophysical and socioeconomic conditions. Analysis of the distribution of RDs across ecological zones indicate that more than 70% of the highly suitable areas with high adoption potential are located in the sub-humid and humid zones in Ethiopia, and in the moist semi-arid and sub-humid zones in Kenya and Malawi. The results indicate that, in all countries, the majority of the RDs are located in ecological zones where the crop growing season extends from 120 to 165 days and where biomass production is relatively higher.

The study provided a spatial framework for the transfer of knowledge and technology of CA in Ethiopia, Kenya and Malawi, and the domains developed will facilitate targeting of CA in the three countries. For example, the areas with high suitability and high adoption potential could be used as entry points for targeting CA technologies for successful and fast uptake. It is concluded that RDs for CA can be developed from analysis of high resolution gridded datasets for targeting and prioritizing CA related agricultural research and investment priorities in highly mixed-farming systems in Africa.

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